PLUMBING SYSTEMS IN SUSTAINABLE CONSTRUCTION

ENVIRONMENT IS THE REASON; MONEY IS THE MOTIVATION.

BY WINSTON HUFF, CPD, LEED AP

"Three hundred fifty years ago the architect specified that a grove of trees be planted and maintained to replace the beams in the ceiling when they would suffer from dry rot." This quote from anthropologist Gregory Bateson about the New College, Oxford, illustrates an example of sustainable construction methods.

The quote is part of a story that Bateson told that goes like this: The Oxford College main hall (which is used as a backdrop in the Harry Potter films) was built in the 1600s with beams 40 feet long and two feet thick. About 100 years ago, the beams were found to be suffering from dry rot and replacements were needed. However, no 40-foot straight English oaks were available from mature forest to replace the beams. A young faculty member suggested asking the college forester if appropriate trees could be found on some of the lands that had been endowed to Oxford. When contacted, the forester said, "We've been wondering when you would ask this question. When the present building was constructed 350 years ago, the architects specified that a grove of trees be planted and maintained to replace the beams in the ceiling when they would suffer from dry rot." At the conclusion of the story, Bateson would remark: "That's the way to run a culture."[1]

Over time, our culture has changed, and current building designers, including plumbing designers and engineers, have little concern for buildings after construction is complete. Thus, the sustainable building movement's focus is to develop ways that a building can better sustain its interior and exterior environments throughout its life.

But what is sustainable building, why would the public be interested in it, and why would owners spend the extra money to construct a sustainable building?

Sustainable building methods mimic the way the Earth recycles and cleans water and air in the biosphere. As well as reducing the damage a plumbing system can cause, future sustainable plumbing design and construction will build plumbing systems that help preserve the biosphere. Plumbing sustainability's goal is to respect the biosphere by learning from it and applying its lessons to plumbing system design and construction. This process is called plumbing biospherics.

In other words, the *reason* for sustainable building is to reduce a plumbing system's harmful effects on both the exterior environment and a building's occupants. The *motivation* for building owners to construct and maintain sustainable properties is the money they can save from environmentally efficient buildings.

The purpose of this article is to introduce plumbing engineers to sustainable building methods developed by the U.S. Green Building Council and the Leadership in Energy and Environmental Design building rating system. While the USGBC LEED system is not the only sustainable construction methodology, it is the one that is predicted to have the greatest effect on future building design, construction, and maintenance. This article also covers the types of plumbing systems that can be applied toward LEED certification.

Photo: Alan Mars

Author's Note: *This is the second in a series of articles covering plumbing biospherics. These articles are intended to spark plumbing engineers' imaginations on how future plumbing system technology will develop—by copying the Earth's sustainable biosphere and, as a result, increasing our basic sustainable standard of living.*

The LEED Certification Process

LEED-certified projects are buildings that have completed the LEED rating system registration process and are awarded the certification from the USGBC. LEED-registered projects are those that have registered with the USGBC and are in the review process. It is recommended that you work with LEED Accredited Professionals, who are building professionals who have completed and passed the LEED Accreditation Professional Exam.

The LEED rating system is separated into five credit categories: sustain-

able site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

There are four levels of LEED certification with 69 possible points. A certified building must have a minimum of 26 points. A silver rating is 33 points; gold is 39 points; and platinum is 52 points.

A sustainable building's economic benefits include the returns from a company's most expensive cost: its employees. Office workers often are dissatisfied with temperature, indoor air quality, acoustics, and lighting; thus, productivity suffers. For example, the West Bend Mutual Insurance Co. documented a 16 percent productivity gain in the early 1990s due to its new 150,000-square-foot green building, which incorporates daylighting, individually controlled workstations, connectivity to nature, and improved lighting. With an annual payroll of $13 million at that time, the increase was worth more than $2 million each year. Energy costs also were reduced by an estimated 40 percent.

Buildings with healthy indoor environments also are easier to lease and have a higher resale value because a greater percentage of the buildings is occupied.

Once a building owner and the design team have decided to work toward LEED certification, the first step is to register the project with the USGBC. Refer to the USGBC Web site (www.usgbc.org) for complete details on the process. Registration requires submitting detailed building information, as well as paying a fee. This also is the time to purchase copies of the rating systems. (See sidebar "LEED Products" for a brief overview of current and soon-to-be-released rating systems.)

After registering, the team gains access to different sections of the USGBC's Web site and receives LEED templates and online project listings. This year an online electronic submission process will be available.

The design and construction team now should start reviewing the rating systems to determine which points they can obtain for their project. Each point requires submission of drawings, letters, or calculations to the USGBC. The Credit Inquiries and Rulings (CIR) section of the USGBC Web site—to which you receive access after registering—can help clarify some frequently asked questions.

The team should collect the required data during the design and construction process, which can last months or longer. When the drawings, letters, calculations, and material cutsheets are ready, the team can submit them to the USGBC for review. After the review process is complete, the building receives a certification. It is important to remember the LEED certification is not a simple process; it requires a committed effort by the entire design and construction team throughout the building's development.

Major LEED Points for Plumbing Systems

LEED points are awarded for plumbing building materials, construction methods, plumbing equipment energy efficiency, sanitary sewer systems, storm water systems, and potable water systems. Points that involve plumbing systems are obtained by using water-reducing plumbing fixtures and materials made with recycled content, harvesting storm water, and reducing potable water usage.

Green Roofs. One of the first points that applies to the plumbing system design is Sustainable Sites Credit 6.1, which requires, "No net increase in the rate and quantity of storm water runoff from existing to developed conditions; OR, if existing imperviousness is greater than 50%, implement a storm water management plan that results in a 25% decrease in the rate and quantity of storm water runoff," according to the *LEED Reference Guide Version 2.0*.

The installation of a green roof can help in obtaining this credit. To understand why, it is important to understand the intent of a green roof in a sustainable building.

The USGBC currently is addressing one of urban sprawl's most negative effects: the replacement of green spaces with hard surfaces such as roofs and parking lots. On a large scale, impervious surfaces can cause flooding that contaminates streams and rivers. In some areas, combined sanitary and storm sewer systems are too small to handle heavy rains, which causes raw sanitary sewage to be dumped into rivers and streams.

A sustainable building with a green roof reduces the amount of impervious surfaces, such as roofs, in a project. Another advantage of a green roof is that it can help reduce the amount of storm water that leaves the building site. The use of a green roof along with open grass areas on a site can increase a site's pervious rate and, as a result, reduce the project's effect on the existing storm water system.

Irrigation Reduction. Plumbing engineers also can design landscaping systems that obtain Water Efficiency credits. One point is available from WE Credit 1.1: "Use high efficiency irrigation technology, OR, use captured rain or recycled site water to reduce potable water consumption for irrigation by 50% over conventional means." Another point is available in WE Credit 1.2: "Use only captured rain or recycled site water for an additional 50% reduction (100% total reduction) of potable water for site irrigation needs, OR, do not install permanent landscape irrigation systems." The sustainable goals for these points are to reduce or eliminate potable water use in the irrigation system.

The installation of an irrigation monitoring system that operates on timers or sensors in the ground and only waters the landscaping in dry conditions can help in obtaining this point. Other ways include using indigenous or drought-resistant plants that do not require watering and collecting storm water in tanks for use in irrigation.

Waterless Urinals. WE Credit 3.1 offers one point when you "Employ strategies that in aggregate use 20%

How Do Buildings Affect the Environment?

- Buildings use 62.2 percent of total U.S. electricity consumption.
- Buildings comprise more than 36 percent of total U.S. primary energy users.
- Buildings produce 30 percent of total U.S. greenhouse gas emissions.
- 136 million tons of construction and demolition waste are generated in the United States per year (approximately 2.8 pounds per person per day).
- Buildings use 12 percent of the potable water in the United States.

Sources: U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Geological Service, Worldwatch Institute

less water than the water use baseline calculated for the building (not including irrigation) after meeting Energy Policy Act of 1992 fixture performance requirements."

An inexpensive way to obtain this point is to use waterless urinals in male rest rooms. The LEED calculation is based on the occupancy of a building in which half of the occupants are males who use a toilet once and a urinal twice a day. The base calculation, as outlined in *LEED Reference Guide Version 2.0*, uses one-gallon flush-type urinals. When waterless urinals are used in the design calculation, two gallons of water per male occupant are saved per day. As a result, using the LEED calculation, a 20 percent reduction in water use can be achieved by using waterless urinals.

Waterless urinals have special traps with liquid seals that allow urine to pass though to the sewer system while keeping the sewer gases out of the rest room. Because there is no flush, they reduce the amount of airborne bacteria that can be expelled during the flushing action of a flush urinal. Their simple daily cleaning routine can be incorporated in the regular housekeeping activities. The traps have a limited life and will require replacing.

However, building owners don't always readily accept these fixtures when presented with them for the first time. Plumbing designers should consult housekeeping officials early in the design process to ensure they are comfortable with these fixtures. Waterless urinal vendors and manufacturers are very aware of these issues and are always available to assist in the educational process.

Low-Flow Fixtures. WE Credit 3.2 offers another point when you "Exceed the potable water use reduction by an additional 10% (30% total efficiency increase)." Plumbing engineers can reduce water consumption further by using low-flow fixtures. Manufacturers now have available low-flow, 1.2-gallon water closets and ultra-low-flow water closets that use 0.8 gallons per flush. Dual-flush toilets that have two levers—one for urine that uses one gallon and one for solid waste that uses 1.6 gallons—are also available, if acceptable to the local jurisdictional authority. These fixtures have been used in Europe and Australia for years. Some have four-inch pathways that reduce the amount of clogs in the trap.

The base design for LEED allows for 2.5-gallons-per-minute lavatories. Low-flow lavatories are rated at 1.8 gpm. The base design for showers is 2.5 gpm, and low-flow showers are rated at 1.8 gpm. You can incorporate low-flow lavatories and showers in the project with little added expense.

Many sustainable buildings have bike racks to encourage occupants to bike to work rather than drive. Because of this, there is a LEED credit for providing a bike rack at the building. While this credit also requires the building to have showers for 10 percent of the occupants, these showers do not necessarily add water usage to the water efficiency calculation baseline. Low flow, 1.8-gpm shower heads can be installed to help in obtaining the reduced water LEED point. Low-flow lavatories and sinks and metered lavatories also can help in getting the reduced water consumption credit.

Gray Water Systems. The water reduction methods described to this point are inexpensive options that can be installed in a typical building by slightly modifying the plumbing design. If an owner wants to apply for silver,

LEED Products

The U.S. Green Building Council has developed the following rating systems for different property types. Committees comprising members from each of these fields develop these guidelines. USGBC also encourages and needs input from practitioners in the market. For more information on membership and the organization, visit www.usgbc.org.

LEED for New Construction and Major Renovations (LEED-NC). This is the current rating system for buildings. It is intended for many different building types, including offices, schools, multifamily properties, and laboratories. By late 2004, 137 projects were LEED-NC certified and 1,615 projects were registered.

LEED for Existing Buildings (LEED-EB). Tailored to sustainable buildings constructed before the LEED-NC system was created, this rating system focuses more on building operations, maintenance, and data collection. Recently released, LEED-EB is expected to be the most popular LEED product. As of November 2004, eight buildings were certified and 100 buildings were registered in the pilot program.

LEED for Commercial Interiors (LEED-CI). Recently released, this rating system was created for tenants that build out space in leased buildings. It is designed to be used with LEED-CS.

LEED for Core and Shell Development (LEED-CS). Currently a pilot program, this rating system is designed for the shell of buildings that may or may not have tenant build outs obtaining the LEED-CI rating. It is scheduled for public release later this year.

LEED for Homes (LEED-H). This rating system designed for the residential housing market is due for public release in 2006.

LEED for Health Care (LEED-HC). Designed for the special needs of the health care market, this system is due for public release in 2006.

LEED for Labs (LEED-LAB). This rating system is designed for the special needs of laboratories and is scheduled for public release in 2006.

Photo: David Ropinski

gold, or platinum LEED certification, plumbing designers might need to use more complex systems that add front-end costs to a project.

WE Credit 2.0 is a good example of this. You can earn one point if you "Reduce the use of municipally provided potable water for building sewage conveyance by a minimum of 50%, OR, treat 100% of wastewater on site to tertiary standards."

One design option to meet this credit is collecting the building's storm water and reusing it in the building's nonpotable water fixtures. Often called storm water harvesting, this system collects storm water in storage vessels and pumps it to a separate water distribution system from the potable system that only feeds the water closets and other nonpotable water fixtures. If using this type of system, you will need to connect to the building's potable water system for backup, which will require a backflow prevention device to protect the potable water system. Close coordination with plumbing and health code officials is required when installing such a system.

Composting Toilets. Another option to obtain WE Credit 2.0 is including systems utilizing composting toilets, which are growing in popularity and require little water to operate. The room exhaust pulls room air into the toilet fixture and then out of the building to reduce smell.

These fixtures require a room under or adjacent to the rest room for the composting equipment. While this system is not feasible for all projects, it can meet the special needs of certain projects, particularly remote facilities with limited water and sewer access. In addition, composting toilet systems can work well in nature centers and state parks or facilities that can use the compost for landscaping.

The LEED rating system covers other fixtures, energy-efficiency issues, and designs that relate to plumbing systems; unfortunately, there is not enough room in this article to cover details for them all. For example, recycled content in plumbing fixtures can be applied toward LEED points. Another example is water heating systems that use solar power.

Design Approach

Sustainable construction requires a different approach to building design. Communication and coordination among the designers, contractors, local authorities, and users are very important.

The water efficiency irrigation and storm water management points in the sustainable site credits illustrate this fact. These are typically points that the civil engineer or landscape architect directs; however, the civil engineer and landscape architect will need to coordinate with the plumbing engineer who might need to perform the USGBC calculations required for these points.

Another way to illustrate this idea is to consider storm water when it comes into contact with a building. When the water is on the roof, traditionally it is the plumbing engineer's responsibility to get it off the roof and off the site as fast as possible. In the plumbing system, storm water is a waste product to be rejected. At the same time, potable water coming into a building is a valuable commodity to be preserved and distributed via an elaborate piping system. To build a sustainable system, the plumbing engineer must consider the building as a whole and determine if there is a way to reduce the amount of potable water used in the building by using storm water. The landscaping irrigation system may be a good fit. As a result, the storm water runoff into the municipal sewer system and the amount of potable water needed for a building are reduced. The building's effect on the exterior environment is diminished. As stated in the title of the article, the environment is the reason for these design changes.

The owner then pays less over the life of the building for potable water usage and, through the LEED rating system, receives credit for this effort, which raises the facility's value. Thus, money is the motivation.

The designers and builders of the Oxford College main hall in the 1600s knew the building would last more than 300 years, and they made provisions for the beams' eventual replacement. Today's designers and contractors need to take a different look at their buildings to see beyond the front-end budget or the construction's environmental effects. They need to consider the building's operation during its entire life. This is sustainable building and plumbing biospherics. ■

References

1. McDonough, William. "A Centennial Sermon: Design, Ecology, Ethics, and the Making of Things." The Cathedral of St. John the Divine, New York. Feb. 7, 1993.

What Is the U.S. Green Building Council?

USGBC is a national nonprofit and nongovernmental organization. It is a voluntary, consensus-driven, and committee-based rating system developed and maintained by building owners, designers, and contractors. Its third-party review method brings meaning to the term *sustainable construction*.

Its mission is to promote the design and construction of buildings that are environmentally responsible, profitable, and healthy places to live and work.

The organization's activities include the following:

- Integrate building industry sectors, incorporating sustainable methods from design to construction and during building operations.
- Lead market transformation: The more sustainable products are used the more they will be made.
- Educate owners and practitioners on sustainability.

Winston Huff, CPD, LEED AP, is a project manager, plumbing fire protection designer, and LEED facilitator with Smith Seckman Reid Consulting Engineers in Nashville, Tenn. He is the founding editor of Life Support and Biosphere Science academic journal and has served as its editor in chief. He also is president of Science Interactive, an organization promoting biosphere science (www.scienceinteractive.net). *Contact him at* whuff@ssr-inc.com.